

REMARKS

The applicants appreciate the Examiner's thorough examination of the Application and request reexamination and reconsideration of the Application in view of the following remarks.

The subject invention results from the realization that, in a feedback system where the output closely tracks the input, the error signal is small, and so rather than sample both the input and feedback signals before taking the difference to create the error signal, it is better to form the error signal with a continuous-time (non-sampling) circuit followed by a gain stage and then sample this amplified error signal using a switched-capacitor circuit. This novel arrangement causes the input-referenced switch thermal noise to be reduced by the amount of the gain used in the error path. The amount of gain that can be used in the error path depends on how closely the output tracks the input; it is desirable to make this gain as large as possible without causing the error signal to exceed the supply voltage.

Claims 4-6, 9 and 10 stand rejected under 35 U.S.C. §102(e) as allegedly being anticipated by U.S. Patent No. 6,304,608 to Chen et al. in view of U.S. Patent No. 5,805,093 to Heikkilä et al. The Examiner notes that this rejection is a multiple reference 35 U.S.C. §102 rejection.

Applicants herein amend independent claims 4 and 9 to recite that the input circuit receives a signal non-sampled by a switch capacitor circuit and providing a signal representative of the difference between the input signal and the quantized signal. Support for this amendment can be found at page 4, lines 9-15 of the subject application. The claimed invention, as noted above, provides a signal non-sampled by a switch capacitor circuit to a gain amplifier to reduce the input referenced switch thermal noise by a factor of

the amplifier's gain.

Chen et al. shows a multi-bit sigma-delta converter that includes, as shown in Fig. 2, a loop filter 22, an N-level quantizer 25, element selection logic 26, and an N-level digital to analog converter (DAC) 27 and a summing device 21. N-level DAC 27, however, samples the feedback signal before it is input into summing device 21. As such, Chen et al. does not disclose or suggest an input circuit for receiving a signal non-sampled by a switch capacitor circuit and providing a signal representative of the difference between an input signal and a quantized feedback signal, as claimed by Applicants.

Also, the Examiner alleges that loop filter 22 of Chen et al. includes an amplifying means, g1, for amplifying a difference signal. From Fig. 2 it is clear that g1 represents only a conceptual gain of integrator H1, but is not an amplifier. To this point, Chen et al. refers to g1 as a "modulator coefficient," rather than an amplifier. See Chen et al. at column 11, lines 51-54. Thus, g1 is not an amplifier, but part of loop filter 22.

Moreover, Fig. 6 of Chen et al., which shows the N-level DAC 60 together with the integrator 53, does not show an amplifier before an input sampling capacitor and a switch. G1, which the Examiner asserts is an amplifier, is therefore part of DAC 60 or integrator 53. Thus, Chen et al. does not disclose or suggest a sigma-delta modulator having an input circuit including means for amplifying a different signal representative of the difference between an input signal and a quantized feedback signal and a filter circuit including at least an input sampling capacitor and switch which introduces thermal noise.

As the Examiner will note, Chen et al. also does not disclose or suggest reducing the input-referred thermal noise by a factor of approximately the gain of the amplification because Chen et al. does not disclose an amplifier before a switch.

The subject invention as claimed includes an input circuit that includes either means for amplifying a non-sampled difference signal representing the difference between an input signal and a quantized feedback signal or a summing circuit for providing a difference signal and an amplifier for amplifying the non-sampled difference signal. One means for amplifying the difference signal is amplifier 40 as shown in Figs. 1 and 2 of the subject application. Another is summing amplifier 11A as shown in Fig. 3 of the subject application. Chen et al. does not disclose or suggest either a means for amplifying the non-sampled difference signal or an amplifier for amplifying the non-sampled difference signal because g1, which the Examiner asserts is an amplifier, is in actuality part of DAC 60 or part of integrator 53 which is after switch 50.

In contrast to Chen et al., claim 4 of the subject application recites: “A $\Sigma\Delta$ modulator with a filter system having reduced switch thermal noise comprising: an input circuit for receiving an input signal and a quantized feedback signal non-sampled by a switch capacitor circuit and providing a signal representative of the difference; a filter circuit including at least an input sampling capacitor and switch which introduces thermal noise error; a quantizer circuit for quantizing the output of said filter circuit; a feedback circuit, responsive to said quantizer circuit, for delivering to said input circuit said quantized feedback signal; and said input circuit including means for amplifying said difference signal, before it is submitted to said filter circuit to reduce the input-referred thermal noise by a factor of approximately the gain of the amplification” (emphasis added). Chen et al. does not disclose or suggest an input circuit for providing a signal non-sampled by a switch capacitor circuit and that is representative of the difference between an input signal and a quantized feedback signal. Chen et al. does not disclose or suggest a

means for amplifying the non-sampled difference signal before it is submitted to a filter circuit.

Also in contrast to Chen et al., claim 9 of the subject application recites: “A $\Sigma\Delta$ modulator with a filter system having reduced switch thermal noise comprising: a summing circuit for receiving an input signal and a quantized feedback signal and providing a signal non-sampled by a switch capacitor circuit and that is representative of the difference; a filter circuit including at least an input sampling capacitor and switch which introduces thermal noise error; a quantizer circuit for quantizing the output of said filter circuit; a feedback circuit, responsive to said quantizer circuit, for delivering to said summing circuit said quantized feedback signal; and an amplifier circuit for amplifying said difference signal, before it is submitted to said filter circuit to reduce the input-referred thermal noise by a factor of approximately the gain of said amplifier circuit”. (Emphasis added.) Chen et al. does not disclose or suggest an input circuit for providing a signal non-sampled by a switch capacitor circuit and that is representative of the difference between an input signal and a quantized feedback signal. Chen et al. also does not disclose or suggest an amplifier circuit for amplifying the non-sampled difference signal between the input signal and a quantized feedback signal.

The Examiner alleges that Heikkilä et al. overcomes the deficiencies of Chen et al. because it allegedly shows that a switching circuit is inherently a part of a sigma-delta modulating system. However, despite that Heikkilä et al. shows a switching system in Fig. 2, the combination of Heikkilä et al. and Chen et al. actually teaches away from the subject invention. In particular, Fig. 1 of Heikkilä et al. shows “scaling means” 17 which is shown in greater detail as a switching system in Fig. 2. Thus, Heikkilä et al. in actuality teaches to

those of ordinary skill in the art that a scaling means is a switching system, rather than an amplifier, which further supports Applicants' arguments above that g1 of Chen et al. is not an amplifier. In other words, Heikkilä et al. teaches that g1 of Chen et al. is part of a switching system rather than a means for amplifying or an amplifier as the Examiner asserts. Thus, the combination of Chen et al. and Heikkilä et al. not only does not produce the subject invention, it actually teaches away from the subject invention.

Accordingly Chen et al. and Heikkilä et al., either alone or in combination, do not disclose or suggest the subject invention as claimed. Applicants respectfully request that the Examiner withdraw the rejections under 35 U.S.C. §102(e).

Each of the Examiner's rejections has been addressed or traversed. Accordingly, it is respectfully submitted that the application is in condition for allowance. Early and favorable action is respectfully requested.

If for any reason this Response is found to be incomplete, or if at any time it appears that a telephone conference with counsel would help advance prosecution, please telephone the undersigned, or his associates, collect in Waltham, Massachusetts, at (781) 890-5678.

Respectfully submitted,



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